TABLE 4

lists test results for humidity exchange with the counter-current module conducted at room temperature (20.9° C.).

Feed side (Air)			Sweep side (Ar)			Global performance		
Flow rate,	H_2O molar fraction		Flow rate,	H_2O molar fraction		Water permeance,	H_2O/N_2	
L/s	Outlet	Outlet	L/s	Inlet	Outlet	mol/m^2/s/Pa	selectivity	Gain/loss
0.103	0.0182	0.009	0.208	0	0.0053	1.1E−5	146.5	1.04
0.103	0.01	0.0061	0.102	0	0.0042	8.0E−6	148.3	1.14
0.103	0.0182	0.0076	0.102	0	0.0070	8.4E−6	156.8	0.94
0.103	0.06	0.0038	0.102	0	0.0026	8.3E−6	71.7	1.07

Performance of the module was characterized using a global water permeance value and an H_2O/N_2 separation factor. Water permeance and separation factors measured from the humidity exchange are close to values measured for air dehumidification. TABLE 5 compares humidity and thermal exchange results obtained for the same module.

TABLE 5

Testing results of counter-current module for humidity and heat exchange.*

Feed side (house air)					Sweep side (house air)					
Inlet			Outlet		Inlet		outlet		Global performance	
T (° C.)	F (l/s)	x_{H2O}	T (° C.)	x_{H2O}	T (° C.)	F (l/s)	T (° C.)	x_{H2O}	P_{H2O} (mol/m^2/s/Pa)	k_h (w/m^2/k)
24.7	0.051	0.01	22.4	0.007	21.9	0.051	23.7	0.004	3.8E−06	39.3
28.1	0.051	0.01	22.9	0.0073	21.5	0.051	25.6	0.004	3.8E−06	34.5
31	0.103	0.01	25.5	0.0065	23.3	0.103	27.6	0.0054	1.2E−05	50.8
32.3	0.103	0.01	25.3	0.0043	22.5	0.103	28.8	0.0045	1.2E−05	66.2
29.6	0.154	0.01	24.9	0.0076	22.5	0.153	27	0.0043	1.2E−05	88.5
32.3	0.103	0.01	25.3	0.0043	22.5	0.103	28.8	0.0045	1.2E−05	66.2
32	0.103	0.014	25.2	0.0091	22.4	0.103	28.2	0.007	1.1E−05	58.2
31.6	0.103	0.018	25.2	0.0096	22.5	0.103	27.7	0.0087	1.1E−05	52.2

*Feed air linear velocity = 5.13 m/s; Sweep air velocity = 6.12 m/s

The flow path of the membrane sheet is only about 4 cm. Significant changes in temperature and humidity between the inlet and outlet of feed and sweep gas streams with such short residence times (~8 ms) suggest that both heat and humidity exchange rates are rapid. Mass and heat exchange rates of the counter-current module are characterized with global water permeance values and heat exchange coefficient values, respectively. Water permeance increased with the feed and sweep air velocity. Water permeance values in the table are consistent with water permeance values measured from air dehumidification tests. Heat exchange coefficient values listed in the table are in line with gas-phase heat exchange values for conventional metal plate heat exchangers. Thus, membrane device is promising for enthalpy recovery in addition to air dehumidification.

While various preferred embodiments of the invention are shown and described, it is to be distinctly understood that this invention is not limited thereto but may be variously embodied to practice within the scope of the following claims. From the foregoing description, it will be apparent that various changes may be made without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A membrane device, comprising:

two or more membrane cassettes disposed in a stack of membrane cassettes comprising at least a first membrane cassette and a second membrane cassette, each membrane cassette comprising

porous metal membranes disposed on respective faces of a support frame, the support frame defining an open space and comprising a plurality of depressions located on opposing faces of the support frame, and a plurality of permeate or sweep flow slots located on one edge or both opposing edges of the support frame and in fluid communication with the open space;

wherein a first plurality of depressions on the first membrane cassette are connectable to a second plurality of depressions on the second membrane cassette to form a plurality of feed flow slots in the stack of membrane cassettes, the plurality of feed flow slots and the plurality of permeate or sweep flow slots being located on respective sides of the stack of membrane cassettes with flow paths that transport selected fluids across the surfaces of the porous membranes in the membrane cassettes during operation that provide separation or filtration of particulates or certain molecules from the fluids introduced into the membrane device.

2. The membrane device of claim **1**, wherein the support frame comprises a first half frame comprising a plurality of